Anytime Virtual Labs on Portable Media and As Debian Packages

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Any Time Virtual Labs: On Portable Media and As Debian Packages

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***Abstract*—As education and technology merge, the diversity of teaching and learning methods expand even more. Virtual labs are a set of web applications containing learning materials that compliment the various courses in an Engineering curriculum. The primary intent of the virtual labs is to provide in-lab experience to their users even when the physical lab infrastructure is not available. In this paper, we propose a method for providing access to virtual labs for all those lack internet access. Our aim is to facilitate availablility and usage of Virtual Labs without network connectivity. We preinstall the virtual labs with full environment on an Operating System and also use Debian packages for easy installation of the labs on existing Operating System.**

***Keywords*—Ubuntu Customization Kit, Customised Operating System, Debian Packaging, Virtual Labs, Limited Network Connectivity, Portable Media, Automation**

I. Introduction

Laboratories play a pivotal role in engineering studies. The laboratory experience of using instruments and materials encourage students in exploring advanced skills through self motivated discovery learning [1]. However, many experiments cannot be conducted in real laboratory setting for various reasons like cost, lack of resources and the risks involved. Unfortunately, many colleges and schools across the world lack the presence of labs at their disposal. As a result, governments and educational organizations are now taking up initiatives in setting up virtual laboratories to augment current learning infrastructure.

Virtual labs present a way to convey and learn subjects using visualizations and computer generated simulations. Experiments can now easily be simulated in a virtual environment with no fear of physical damage and at relatively low cost. A virtual lab includes a supportive learning environment to help interested students in exploring the field in more depth. Every virtual lab contains learning material, theory behind the experiment, an instruction manual to guide students in the experiment, quizzes and most importantly a virtual environment for conducting experiments [2].

Physically, a Virtual Lab is a directory containing the web application for running the lab and various other support files which contain the specifications of the lab for future development.

However, this idea also had certain limitations. It required network connectivity which is very limited and sometimes non-existent in the developing and under-developed parts of the world[12]. Also, setting up the client side environment in the machine is no easy task. It requires a good knowledge of support applications. This limits the access to those with a good background in computers.

To handle these limitations, we integrated the network requirements of the Virtual Labs to the local system itself. We created Operating Systems with all the server-side and client-side technical dependencies preinstalled. Then, we setup all the Virtual Labs in the Operating Systems. After that, we configured the Operating System to be able to host all the virtual labs on its local server without any necessity for external support. For making the Debian packages, individual labs were taken and packed along with their dependencies using the standard Debian packaging process [9] with some modifications. The final process can be found here [8]. This confirmed the working of the labs on the system with no further modifications required to be made by the user.

This solution has been currently tested and implemented with 17 virtual labs of diverse fields of different universities with successful results. The implemented labs can be found on Operating System package of size 2.5 Gigabytes[10] and Debian packages (size completely depends on the lab). [11].

II. Approach

All virtual labs are associated with lab specifications. Each specification may vary from the the other. The lab specification file (labspec.json) specifies the requirements of the given lab. All dependencies of the labs are referred from this file.

```
.........Rest of Code................
"runtime_requirements": {
  "platform": {
  "arch": "i386",
  "hosting": "dedicated",
  "installer": ["sudo apt-get update"
              ,"sudo apt-get install
                -y php5 apache2"
               ],
  "lab_actions": {
  "init": ["mv /var/www/index.html
            index.html.default",
            "cp -r ../build/*
            /var/www/"
          ],
  "pause": [], "resume": [],
  "shutdown":["service apache2 stop"],
  "start":["service apache2 start"],
  },
...........Rest of code.........
```

Listing 1: Snippet of labspec.json file

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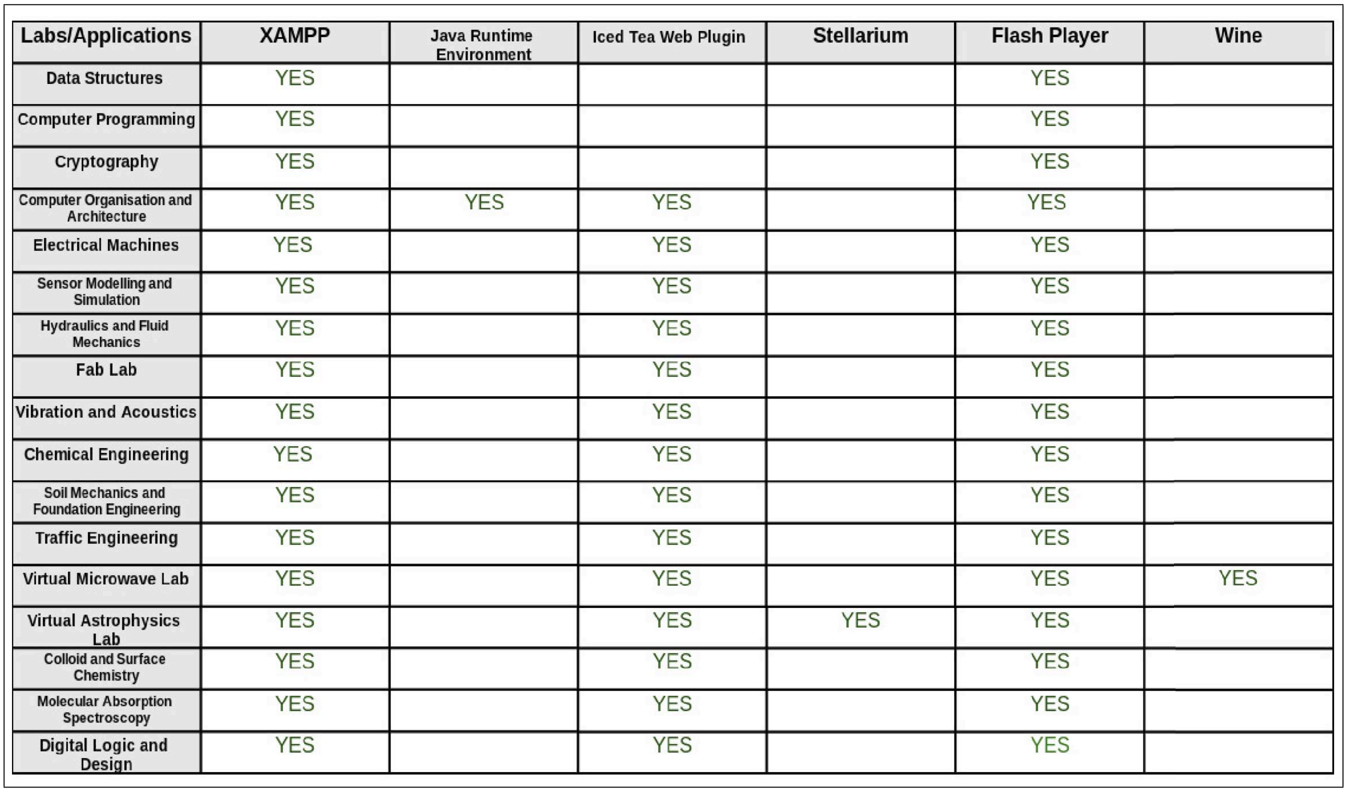


Labs/Applications	XAMPP	Java Runtime Environment	Iced Tea Web Plugin	Stellarium	Flash Player	Wine
Data Structures	YES				YES	
Computer Programming	YES				YES	
Cryptography	YES				YES	
Computer Organisation and Architecture	YES	YES	YES		YES	
Electrical Machines	YES		YES		YES	
Sensor Modelling and Simulation	YES		YES		YES	
Hydraulics and Fluid Mechanics	YES		YES		YES	
Fab Lab	YES		YES		YES	
Vibration and Acoustics	YES		YES		YES	
Chemical Engineering	YES		YES		YES	
Soil Mechanics and Foundation Engineering	YES		YES		YES	
Traffic Engineering	YES		YES		YES	
Virtual Microwave Lab	YES		YES		YES	YES
Virtual Astrophysics Lab	YES		YES	YES	YES	
Colloid and Surface Chemistry	YES		YES		YES	
Molecular Absorption Spectroscopy	YES		YES		YES	
Digital Logic and Design	YES		YES		YES	

Fig. 1: Application requirements of the implemented labs

As we can observe the file contains **JSON** objects. Inside the object *"runtime requirements"* in the object *"installer"*, we have the set of commands which are required to install the server-side requirements of the Virtual Lab. This was used to get the server-side requirements of the Lab.

A. Building the Customised Operating System for the Portable Media(USB Drive):

The major part of the project aims at developing an Operating System with all the Virtual Labs and a fully functional support environment with the labs preinstalled. This will remove the necessity of a network in using the labs and also reduce a significant amount of labour in installing the environment.

Firstly, we needed a base Operating System which is easily customisable and available universally. For this, Ubuntu was decided upon as the best option because it is a freeware and also properly supported.

Next, we needed an application that is able to customise the root of a base Ubuntu image and install the extra packages needed in the image itself. For this, **Ubuntu Customisation Kit** available in the *Ubuntu Software Centre* was chosen.

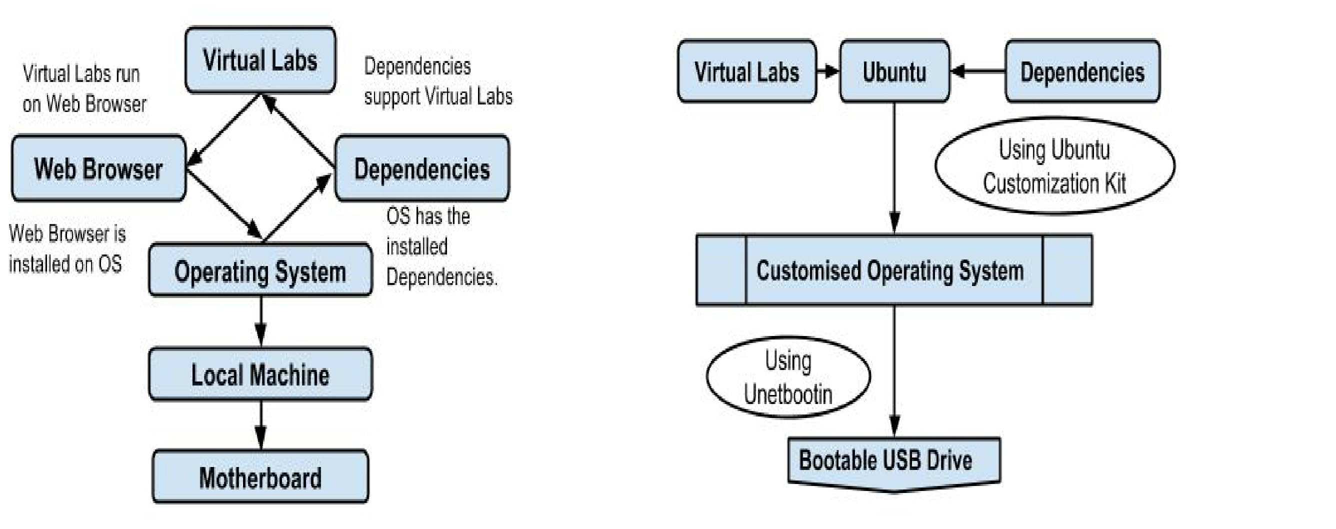
Our first target was to integrate the server and the machine. So, we set out by using basic applications for implementing local servers and databases, i.e, **php5**, **apache2** and **MySQL**. Later in the project, some applications did not support the framework(discussed later in the section). So we switched to XAMPP stack for handling the local server and databases on the system. With this, we were able to meet the server-side requirements of the labs.

The next major task was to setup the Virtual Labs. To accomplish this, we took all the labs (which are directories as mentioned earlier in the Introduction section) and put them in the directory by XAMPP for hosting the web application(*/opt/lampp/htdocs/*). This step confirmed that the web applications will be properly hosted.

The final step was to setup the client-side environment on the system to run all the labs with full functionality. This is the most difficult step of the process as different labs require different support. Also the lab specifications of the lab only mentioned the server-side requirements. So, we had to start out by checking each page of the labs to find out its client-side dependencies. The results we found out are shown in figure 1.

In figure 1, we can clearly observe the diversity of client-side requirements of the Virtual Labs. After recognizing the dependencies, we started installing them on the system. This is the step where we found out that the application *Wine* is not compatible with php5 and apache2 combination and so we switched to XAMPP stack which resulted in the proper running of the *Wine* application.

But XAMPP did not support previously installed default flash-player plugin. So, we had to search for its alternatives too and install the plugin manually. The next challenge was running the .jnlp files which were not supported by the Ubuntu default browser, i.e, Mozilla Firefox. To take care of this, we had to setup Java Environment on the system and also load the *Icedtea web plugin* for supporting the .jnlp files. Upon running it, we had issues with using a 64-bit architecture. So we had to switch to a 32-bit system and repeat the process. The installation of the the Stellarium package was a comparatively easier task.


Virtual Labs run on Web Browser
Virtual Labs
Dependencies support Virtual Labs
Web Browser
Dependencies
Web Browser is installed on OS
OS has the installed Dependencies.
Operating System
Local Machine
Motherboard
Virtual Labs
Ubuntu
Dependencies
Using Ubuntu Customization Kit
Customised Operating System
Using Unetbootin
Bootable USB Drive

(a) Abstraction Layer of the Customised Ubuntu

(b) Making the Customised Ubuntu

Fig. 2: Making the Portable Media with preinstalled Virtual Labs.

After all these major steps, the Virtual Labs were fully functional on the system. But then, this project was designed for making the users comfortable. So, some small changes like running the XAMPP server upon boot and setting the default page of Firefox to **http://localhost/** were made to enhance user experience. All these changes were appropriately made using **Ubuntu Customization Kit** and the Customised Ubuntu Operating System was ready.
The above procedure outlines the process of building the customised operating system. The full documentation is available in [7]. For the latest version of this Customised Operating System, refer [4].

B. Building the Debian Packages:

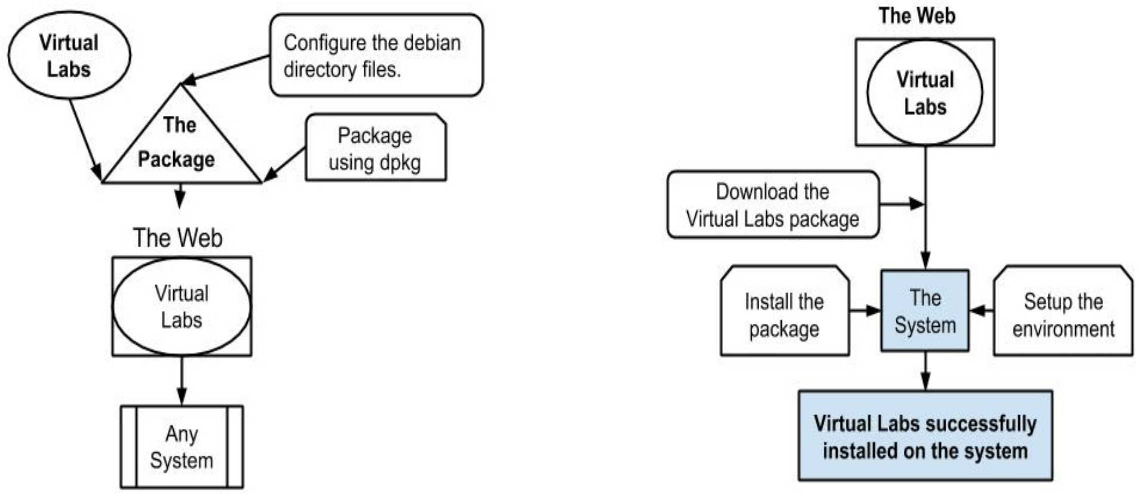
The second part of this project aims at building debian packages for the Virtual Labs. This would help the user in directly setting up a lab in his current Operating System using a single command.
To accomplish the aim, we first had to list out all the dependencies both server-side and client-side which we found out in the section 2.1. Many documentations for building the debian packages were referred [9]and trial and error accomplished each step in the process.
The major step in this process is to make a **DEBIAN** directory inside the Virtual Lab's directory. After that, the **DEBIAN** directory had to consist of the files **control,conffiles,prerm,postint and md5sums**. In this task, only control and md5sums played a major role and they were modified in accordance to the Virtual Lab that was being dealt with. The md5sums was built using a single command line. So, it did not pose much of a problem. But the control file consisted of the data of dependencies, architecture, version and developer. After the **DEBIAN** directory was fully made we only have to run a single line of command(*dpkg -b Directory-Name Destination-of-package/Package-Name-After-Building*). This will package the directory into a .deb format archive. So the Debian Package is ready for use.
Some sample Debian archives can be found on the [5].
Note: The above procedure is just an outline. For more details, refer the full documentation [8]

C. Automating the process

The number of labs are expected to increase as the research fields widen. So we need to make sure that the same problems are not faced in the future. Although both the processes are complex, they have well-defined specific steps which are very similar for all the labs.
So, the third part of the project is aimed at automating the processes. For this, we started with noting the steps required for the processes. The scripts were then made using a combination of *bash* for shell commands and *python* for file handling. Different labs had different dependencies and supports. Keeping these in mind, we made a script for the processes following the same steps as mentioned in the above subsections for both of them respectively.
For working protoype scripts with their *readme* file for help, refer [6].

D. Challenges faced during the approach

- The labs are created on different platforms with different system requirements,it takes hours to install one application working for all the labs.
- The requirement to run .exe files on a Ubuntu system and running .jnlp files on a 32-bit machine took two weeks.
- The labs were not developed based on this idea and so there were a lot of loose ends in the code like the lab linking to external sites and problems with libraries used in the *HTML* pages.
- As the system had to run completely offline the experiments taking online help were substituted by newly made completely offline ones.



(a) Making Debian Packages

(b) Debian Packages in use

Fig. 3: Debian Packaging of the Labs

- Also the client-side requirements were not mentioned in the labspec.json files. So a lot of testing had to be done before the actual process to find out all the dependencies and update the labspec.json file.

III. Limitations of this project

1) We were not able to run **java3d** files and so the labs running Java-applets on java3d platform had to be dropped and alternative is yet to be suggested. The code in the Java-applets was not meant for local servers and we were not able to correct it due to lack of proper understanding of the source code.
2) The experiments of *Computer Organisation and Architecture* lab can be supported only by 32-bit architecture because the *swt* libraries of the .jnlp files used in the experiment supported only 32-bit architecture and for supporting 64-bit architecture we would have to write those from scratch. This was not possible without the guidance of the lab developer.
3) The XAMPP server has to be installed by the users themselves for using the Debian packages because XAMPP stack is not a package for Ubuntu-12.10 and thus we cant include it in the dependencies.

IV. Future Work

We have to overcome the limitations and support all the Virtual Labs available.[3].
Also if the approach is successful, it can be applied to develop graduate college level virtual labs for Medical colleges for expensive experiments.

V. Conclusion

Using the above processes, we were able to develop a Portable Media(USB drive) with 17 Virtual Labs installed on it[10]. We were also able to package the Virtual Labs into Debian Packages making it available on the internet[11]. And finally, we were able to automate both the processes making it easier to include more labs to the list.

References

[1] V. Joolingen and R. Wouter,
Designing Collaborative Discovery Learning, 2000, LNCS, 202-211.

[2] Rohit Ashok Khot and Venkatesh Choppella,
DISCOVIR: A Framework for Designing Interfaces and Structuring Content for Virtual Labs.

[3] Virtual Labs,
http://vlab.co.in/

[4] Updated Customised Operating System,
http://vlead.vlabs.ac.in/2014/05/14/virtual-labs-on-portable-media/

[5] Sample Debian Package,
https://bitbucket.org/akirato/portable-labs-project/src/801494c13eb33d91cc6efc8663b1c4a17ef4cb2c/DebianPackage/Sample%20Debian%20Package/?at=master

[6] Automated Scripts for the Processes,
https://bitbucket.org/akirato/portable-labs-project/src/801494c13eb33d91cc6efc8663b1c4a17ef4cb2c/Automation/?at=master

[7] Instructions for Customising Operating System,
https://bytebucket.org/akirato/portable-labs-project/raw/801494c13eb33d91cc6efc8663b1c4a17ef4cb2c/CustomisedOS/Instructions.pdf

[8] Instuctions for Debian Packaging,
https://bytebucket.org/akirato/portable-labs-project/raw/801494c13eb33d91cc6efc8663b1c4a17ef4cb2c/DebianPackage/Instruction.pdf

[9] Help Document in Debian Packaging Process,
https://www.debian.org/doc/manuals/maint-guide/build.en.html

[10] Implemented Operating Systems,
http://vlead.vlabs.ac.in/2014/05/14/virtual-labs-on-portable-media/

[11] Implemented Debian Packages,
http://vlead.vlabs.ac.in/2014/07/14/virtual-media-in-debian-packages/

[12] Internet User Statistics by Wikipedia,
http://en.wikipedia.org/wiki/Global_Internet_usage/